David M. Hondula

Director of Heat Response and Mitigation, City of Phoenix, Arizona

Testimony Before the

U.S. Senate Committee on Environment and Public Works

Examining the Effects of Extreme Heat and Weather on Transportation

September 13, 2023

Introduction

Phoenix, Arizona is the hottest large city in the United States. Located in the Sonoran Desert, the City and its more than 1,600,000 residents experience long and hot summers with temperatures routinely exceeding 100°F for four months of the year. This unique position along the climatic gradient of the country's major cities provides Phoenix the opportunity, and arguably the necessity, to be leading the national dialogue about how communities can become more resilient to the risks posed by extreme heat. Summer 2023 has been especially challenging, as Phoenix set a new record with 55 days of temperatures reaching 110°F, including a stretch of 28 in a row that covered nearly the entire month of July. This unprecedented heat—both with respect to its intensity and duration—has made even clearer the significant challenges facing our City, as well as many others across the country, in ensuring that the public is safe, our infrastructure is resilient, and that our communities are thriving, even in the face of high and health-threatening temperatures.

Addressing the Heat Governance Gap

Over the past decade, local governments and the federal government have begun to recognize that there are serious deficiencies in planning for, mitigating, and managing extreme heat. In an analysis of 175 municipal plans from the 50 most populous cities in the United States, researchers found that 'few (plans) include strategies to address (heat), and even fewer cite sources of information' (Turner et al. 2022). Similarly, a 2021 survey of planning professionals

in American cities found that barriers related to human and capital resources were constraining the effectiveness of heat planning (Meerow and Keith 2022). Scholars have called for the creation of more explicit and dedicated staff roles and processes regarding heat across multiple scales and sectors of government, recognizing what has largely been an uncoordinated, ambiguous, and underdeveloped governance framework to date (Keith et al. 2021). This governance gap is especially concerning given that heat ranks among the nation's most impactful weather hazards with respect to public health; heat typically accounts for more fatalities each year in the United States than most other weather hazards combined (Berko et al. 2014).

In an effort to address this governance gap at the local scale, in 2021, the City of Phoenix launched the nation's first publicly funded office focused on heat—the Office of Heat Response and Mitigation (OHRM)—embedded in the structure of local government. This new office works with all of the City departments and additional partners to coordinate and improve programs that help protect people from the dangers of heat and ensure that our city's communities are cooler, safer, and more comfortable for their residents. The local mission of OHRM aligns with that of the National Integrated Heat Health Information System (NIHHIS). NIHHIS is a cross-federal agency collaboration originally developed by the National Oceanic and Atmospheric Administration (NOAA) and the Centers for Disease Control and Prevention (CDC), with a mission to "build societal understanding of heat risks, develop science-based solutions, and improve capacity, communication, and decision-making to reduce heat-related illness and death."

The creation of OHRM in the City of Phoenix and NIHHIS at the federal level acknowledges that extreme heat is very much an intersectional challenge that requires cross-sectoral collaborative thinking and cross-agency engagement. These new initiatives and others also reflect the fact that the challenges posed by extreme heat have not yet been adequately met. Success in building a nation that is more resilient to extreme heat will require engagement across all levels of government and across all sectors of society. The City is honored to submit this testimony to address how we are working to address heat challenges within and through one critical sector: transportation. Effective management and mitigation of extreme heat must incorporate the transportation sector. New innovations and ideas are needed to not only protect transportation users, assets, and workforce from risks posed by extreme heat, but also to leverage our transportation infrastructure and systems as part of the portfolio of solutions that can cool American cities.

Mitigating Heat via the Transportation Sector

A significant body of literature demonstrates that urbanization has a significant effect on local and regional climate (e.g., Krayenhoff et al. 2021). Temperatures in cities are typically higher than those in surrounding areas—especially overnight—because of several different physical processes. Compared to natural landscapes, cities are: (1) constructed of materials that are better absorbers of heat; (2) have more heat-emitting machines including air conditioners and vehicles; and (3) have more complex geometry that can trap heat between buildings rather than it being emitted to space. The transportation sector has a particularly influential role regarding the first two processes: land cover and waste heat emissions.

Pavement, which accounts for 30–40 percent of the total land cover of the Phoenix metropolitan area, is a significant contributor to urban heat. Pavement is a significant contributor to urban heat because of its low reflectivity of solar energy. As such, one strategy that could reduce the impact of pavement on urban heat is to apply materials that increase its reflectivity.

The City is a national leader in the testing and implementation of technologies that alter the reflectivity of road surfaces through our Cool Pavement Program. This program began with pilot tests in 2020 and has now expanded to more than 100 miles of city streets, or approximately 20.5 million square feet. These streets have been coated with a water-based asphalt treatment on top of existing asphalt pavement. The coating is a lighter color to the eye and appears light gray, similar to concrete. More importantly, the coating makes the road more reflective to solar energy. At initial installation, the coating that Phoenix has applied increases road surface solar reflectivity from 12 percent to 33 to 38 percent. Ten months after application, the reflectivity was measured between 19 and 30 percent.

The City of Phoenix has collaborated with Arizona State University to produce an independent, rigorous, and open evaluation of the Cool Pavement Program to further drive innovation and support good decision-making. Key findings from the evaluation study include:

- The surface temperature of streets coated with cool pavement were lower at all times of the day compared to traditional asphalt. This difference was more than 10°F at noon and during the afternoon hours and approximately 2°F at sunrise.
- Nighttime air temperature measured six feet above the cool pavement surface was on average 0.5°F lower than above traditional asphalt.
- The thermal comfort of a pedestrian walking on the sidewalk adjacent to a street coated with cool pavement was not significantly influenced by the treatment. However, a person walking directly on the treated street would experience a reduction in thermal comfort (an increase in mean radiant temperature of 5.5°F) that is approximately equivalent to the difference between walking on asphalt and concrete.
- Sub-surface temperatures measured in the asphalt below the cool pavement coating averaged 4.8°F lower than sub-surface temperatures in untreated streets.

The fourth finding, related to sub-surface temperatures, is particularly important with respect to protection of infrastructure from adverse effects of extreme heat. Because the underlying asphalt itself experiences less thermal strain, the cool pavement coating may ultimately reduce long-term maintenance needs and costs, which could yield substantive economic and environmental benefits. Continued evaluation of cool pavement technologies is needed to fully understand their long-term performance with respect to infrastructure protection and urban heat mitigation. Phoenix's decision to invest in cool pavement program evaluation has already paid significant dividends. The evaluation motivated changes to the products that we are applying, which is catalyzing innovation in the manufacturing sector, supporting well-paying jobs. Phoenix also worked with industry to pioneer a spray application technique for cool pavement that increases efficiency and reduces traffic disruption. The City regularly receives requests from communities all across the country interested to learn more about our experience with cool pavement, and we

are proud to be in a position to help inform and advance the national dialogue about how the transportation sector can lead urban heat mitigation efforts.

The City worked with Senator Kelly and this committee to create the Healthy Streets Program in the Bipartisan Infrastructure Law (BIL) to assist with funding cool pavement projects. The goals of this program include mitigating urban heat islands; improving air quality; and reducing the extent of impervious surfaces, stormwater runoff, and flood risks, and heat impacts to infrastructure and road users. Unfortunately, this program is subject to the annual appropriations process. As such, the City of Phoenix encourages the committee to consider mandatory spending for this program in the next surface transportation bill.

Regarding waste heat, it is estimated that more than 40% of extra heat added to urban environments from energy consumption is related to vehicle use (Sailor and Lu 2004). Phoenix is at the national forefront of vehicle electrification, and the adoption of more electric vehicles will help offset the contribution of the transportation sector to urban heat. Our effort to lead by example as a local government includes conversion of the City's vehicle fleet to alternative fuel. We are already making good progress converting light-duty vehicles and are in the early stages of transitioning heavy-duty vehicles, including our bus fleet. Our bus fleet transition plan includes plug-in battery electric busses and hydrogen fuel cell electric busses, and we anticipate a complete transition to 100 percent zero emission busses by 2040. Our overall fleet transition efforts were recently recognized with the Top Green Fleet Award for 2023 by the National Association of Fleet Administrators.

The City of Phoenix recently received more than $16 million in Federal Transit Administration (FTA) Lo-No grant funding from the Bipartisan Infrastructure Law. This program is essential for supporting our transportation fleet transition. This recent award will support acquisition of battery and fuel cell electric buses, installation of charging and maintenance infrastructure, and maintenance training for personnel. The funding will offset the higher cost of zero-emission buses for planned fleet replacements for up to 12 hydrogen fuel cell buses (FCEB) and up to six battery electric buses (BEB)s, support workforce development, and construct fueling infrastructure and install charging equipment.

We also appreciate the new Charging and Fueling Infrastructure Grant program created in the Bipartisan Infrastructure Law that will help expand the deployment of electric vehicle charging and hydrogen/propane/natural gas fueling infrastructure along designated alternative fuel corridors.

Managing Heat for Transportation Users, Assets, and Workers

The ability of the transportation sector to fully support the mobility needs of communities depends, in part, on how environmental factors including the weather are addressed in transportation system design and operation. For warm weather cities like Phoenix, heat influences the experience of transportation users, especially people who walk, bicycle, or use public transportation (e.g., Dzyuban et al. 2021). Residents tell us that heat impacts the decisions they make about where they will go and how they will get there, which impacts commerce, labor, education, healthcare access, and more. Furthermore, Phoenix has ambitious goals to

increase the proportion of the population that chooses active and/or public transportation modes; to achieve those goals, people must perceive their active or public transportation options to provide sufficient thermal comfort and thermal safety.

The most influential determinant of thermal comfort and safety for active and public transportation users is shade coverage. Shade significantly reduces mean radiant temperature, which is one measure of the cumulative heat load on the human body that accounts for shortwave and longwave radiation (Turner et al. 2023). The City's metropolitan planning organization (MPO), Maricopa Association of Governments (MAG) has created the Active Transportation Plan Toolbox that defines 20 percent as the minimum acceptable shade coverage for pedestrian walking routes based on the climatology of Phoenix. 30 percent is considered to be good shade coverage and 60 percent is excellent. At the 30 percent shade threshold, a typical 20-minute walk is considered safe for an average person on all but the hottest 5 percent of summer days (MAG n.d.). Accordingly, natural and engineered resources that can provide shade, like trees, shade sails, and ramadas, are all critical components of our transportation and public health infrastructure.

The City of Phoenix is accelerating its investments to make more shade available for transportation users. One investment is the City's Cool Corridors initiative, through which we are striving to achieve 200 linear miles with at least 30 percent shade coverage for pedestrians by 2030. The City has also recently launched tree and shade grant programs for community and neighborhood groups, schools, youth centers, and local non-profits. As directed by our Mayor and City Council, we are striving to over-invest in communities that have been historically underserved and where shade is simply lacking places that have been coined "shade deserts" (Turner at al. 2023). Our commitment to address disparities in tree and shade coverage is formalized in the Tree Equity Pledge the City made to the non-profit American Forests in 2021. A further indication of our commitment to address the inequitable burden of heat across our communities is our participation with NOAA as one of four cities in a Heat and Equity Pilot Program.

Phoenix is appreciative of federal resources included in the Inflation Reduction Act and Bipartisan Infrastructure Bill that will help us provide shade for transportation users in the communities where it is most needed. For example, the U.S. Forest Services Urban and Community Forestry Program created through the Inflation Reduction Act aligns well with the City's tree and shade equity goals. The City and our partners have submitted two grant applications: one that will implement a series of tree planting programs in places where shade and cooling are most urgently needed, and a second that would support workforce development to maintain the trees we do have and to grow new ones. Phoenix has also applied to the Environmental Protection Agency (EPA)'s Government to Government Environmental Justice grant program that was created in the Inflation Reduction Act. Our proposal is to create a model Cool Corridor in a neighborhood in South Phoenix that integrate a wide range of features including shade and free publicly accessible chilled drinking water systems that would more fully support neighborhood mobility and connectivity. Shade and heat mitigation elements are also included in Phoenix's 2022 Rebuilding American Infrastructure with Sustainability and

Equity (RAISE) award from the Department of Transportation and our recent proposal to the Promoting Resilient Operations for Transformative, Efficient, and Cost-saving Transportation (PROTECT) grant program. We encourage Congress to continue programs like these in the next surface transportation authorization bill.

The Phoenix Public Transit Department is also working hard to ensure that there is robust shade coverage at our transit stops. More than 70 percent of Phoenix's 4,000 public bus stops have shade structures today, and the department is adding 80 to 100 more each year using local funding sources.

With respect to the City's transportation assets, heat is a stressor that increases failure rates and diminishes lifetimes of several critical components. It is critical for Phoenix to consider and use products that operate well in extreme summer heat just as cold weather cities need to have confidence in their systems during winter weather and freezing conditions. In Phoenix, sidewalk buckling can occur because of high temperatures, which causes the potential for trip and fall incidents. The City is also concerned about the impact of heat on electronic systems in the field that operate traffic signals and streetlights, including diminished lifetimes expected from LED lights. Our traffic signal controller cabinets have fans that provide some cooling, but if the fans were to fail, it would be more likely that traffic signals switch to flash mode due to the equipment's heat sensitivity.

In the public transportation domain, high summer temperatures add strain to the air condition systems, engines, and on-board equipment for city buses, including automated doors, wheelchair ramps and lifts, and electronic components. These are challenges that we recognize and integrate into our procurement processes and into seasonal planning. For example, the air conditioning systems we require on our bus fleet have higher capacity components and quicker cool-down periods after engine start-up and between passenger pick-ups, among other updates that improve their performance in hot weather. Each winter and spring, the City works closely with contractors to ramp up preventative maintenance campaigns in anticipation of the higher failure rates that occur during hot weather.

The City of Phoenix places the utmost importance on the safety of its entire workforce, including those who work outdoors in the summer heat to operate and maintain our transportation infrastructure. Phoenix has recently completed a comprehensive review and update of departmental heat safety plans and protocol following formalized guidance provided by the Arizona Division of Occupational Safety and Health through a new State Emphasis Program aimed to reduce heat-related illness and injury in the workplace.

Recommendations and Conclusions

Phoenix is continuing to closely monitor all federal funding opportunities from the Bipartisan Infrastructure Law and the Inflation Reduction Act to scale up and accelerate our ability to comprehensively address heat through the transportation sector and beyond. We have worked hard to identify opportunities to integrate heat-related elements into a diverse suite of federal funding applications and are confident that significant benefits are being delivered to the community from the support that we have received. We do remain concerned, however, that

communities are constrained in their ability to bring forward the best and most comprehensive heat mitigation and heat response programs for federal support. Our experience is that heat-related projects are not yet fully compatible with legacy language in notices of funding opportunities (NOFOs), as well as in proposal evaluation criteria. Heat is one of our nation's most consequential natural hazards, but its impacts manifest in markedly different ways than the other hazards that have more historical and sustained funding streams. We respectfully ask that the federal agencies and Congress to continue to work to ensure that formula and discretionary programs include heat mitigation and heat response initiatives as project eligibilities, and that the NOFOs and project evaluation criteria more clearly and appropriately acknowledge how heat-related initiatives can be competitive.

Moving forward, continued work to integrate heat planning and thinking across all scales of government, sectors, and agencies will be critical to help pursue community health and prosperity. In Phoenix, we are benefitting from federal engagement and financial support in our efforts to do so, and we look forward for more opportunities for Phoenix and others to achieve even greater impact.

References

Berko, J. (2014). Deaths attributed to heat, cold, and other weather events in the United States, 2006-2010 (No. 76). US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics.

Dzyuban, Y., Hondula, D. M., Coseo, P. J., & Redman, C. L. (2021). Public transit infrastructure and heat perceptions in hot and dry climates. International journal of biometeorology, 1-12.

Hoehne, C. G., Chester, M. V., Fraser, A. M., & King, D. A. (2019). Valley of the sun-drenched parking space: The growth, extent, and implications of parking infrastructure in Phoenix. Cities, 89, 186-198.

Hoehne, C. G., Chester, M. V., Sailor, D. J., & King, D. A. (2022). Urban heat implications from parking, roads, and cars: A case study of metro Phoenix. Sustainable and Resilient Infrastructure, 7(4), 272-290.

Keith, L., Meerow, S., Hondula, D. M., Turner, V. K., & Arnott, J. C. (2021). Deploy heat officers, policies and metrics. Nature, 598(7879), 29-31.

Krayenhoff, E. S., Broadbent, A. M., Zhao, L., Georgescu, M., Middel, A., Voogt, J. A., ... & Erell, E. (2021). Cooling hot cities: a systematic and critical review of the numerical modelling literature. Environmental Research Letters, 16(5), 053007.

Maricopa Association of Governments. Active Transportation Plan Toolbox, accessible online: https://azmag.gov/Programs/Transportation/Active-Transportation/Active-Transportation-Plan/Active-Transportation-Toolbox/Pedestrian-Infrastructure/Shade-and-Thermal-Comfort

Meerow, S., & Keith, L. (2022). Planning for extreme heat: A national survey of US planners. Journal of the American Planning Association, 88(3), 319-334.

Sailor, D. J., & Lu, L. (2004). A top–down methodology for developing diurnal and seasonal anthropogenic heating profiles for urban areas. Atmospheric environment, 38(17), 2737-2748.

Turner, V. K., French, E. M., Dialesandro, J., Middel, A., M Hondula, D., Weiss, G. B., & Abdellati, H. (2022). How are cities planning for heat? Analysis of United States municipal plans. Environmental Research Letters, 17(6), 064054.

Turner, V. K., Middel, A., & Vanos, J. K. (2023). Shade is an essential solution for hotter cities. Nature, 619(7971), 694-697.